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CHARACTERIZATION OF THE SUBSURFACE OF 67P/CHURYUMOV-GERASIMENKO'S ABYDOS SITE

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INTRODUCTION

On November 12, 2014, *Rosetta*'s descent module *Philae* landed on the Abydos site of comet 67P/Churyumov-Gerasimenko (67P). Among the instruments onboard *Philae*, the *Ptolemy* mass spectrometer performed the analysis of several samples collected from the surface and atmosphere of the comet. Here we investigate the structure of the subsurface of the Abydos site. To do so, we employ a one dimensional cometary nucleus model [1] with an updated set of thermodynamic parameters relevant for 67P. The comparison of the production rates derived from our model with those measured by *Ptolemy* allows us to place constraints on the structure of the subsurface of *Philae*'s landing site.

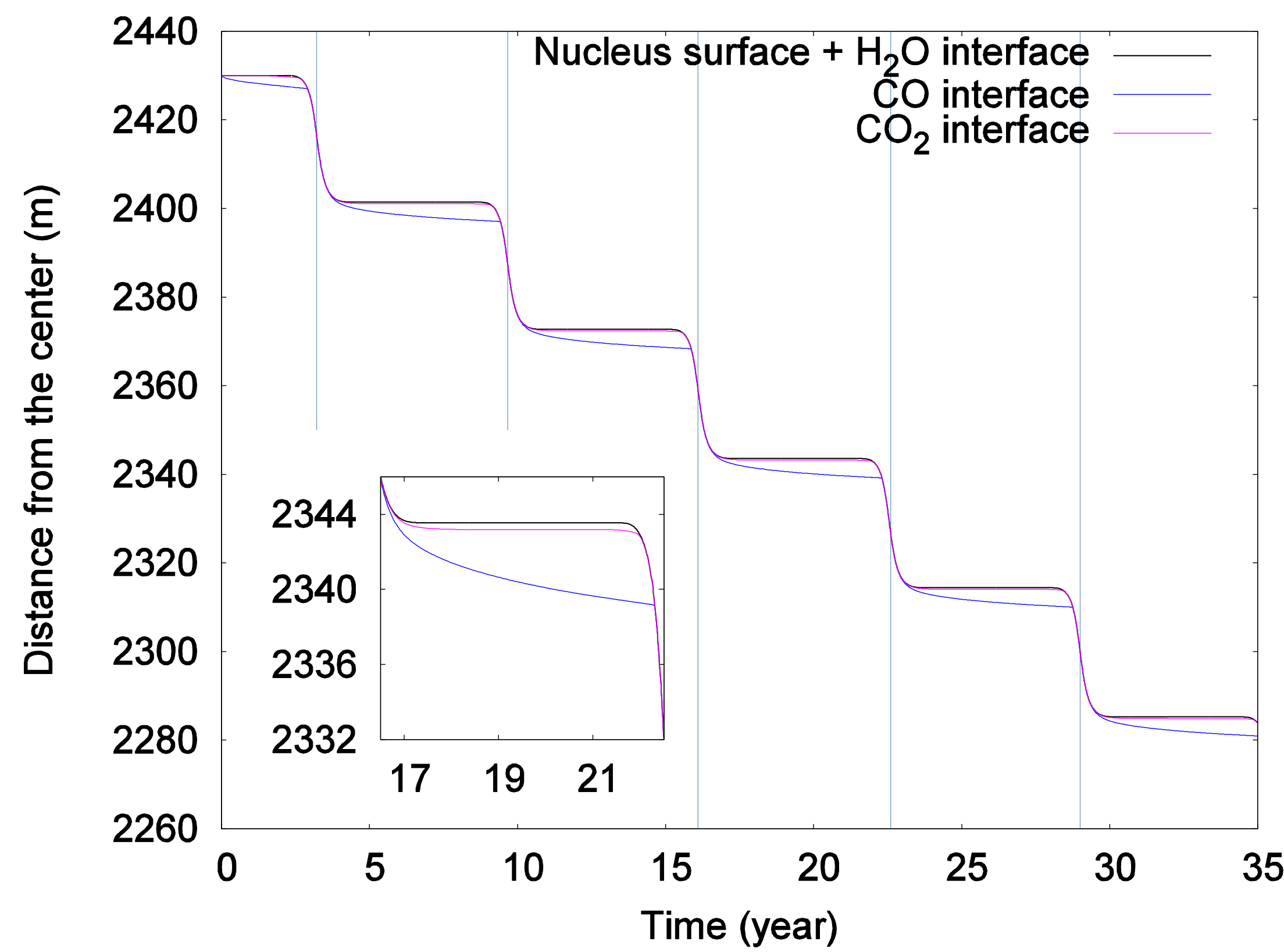


FIGURE 2. Stratigraphy of the nucleus, showing the interfaces of sublimation of all species. An ablation of the surface occurs at each perihelion, reaching all interfaces. Detail of one revolution: the nucleus' physical differentiation has a limited depth because of the low thermal conductivity of 67P.

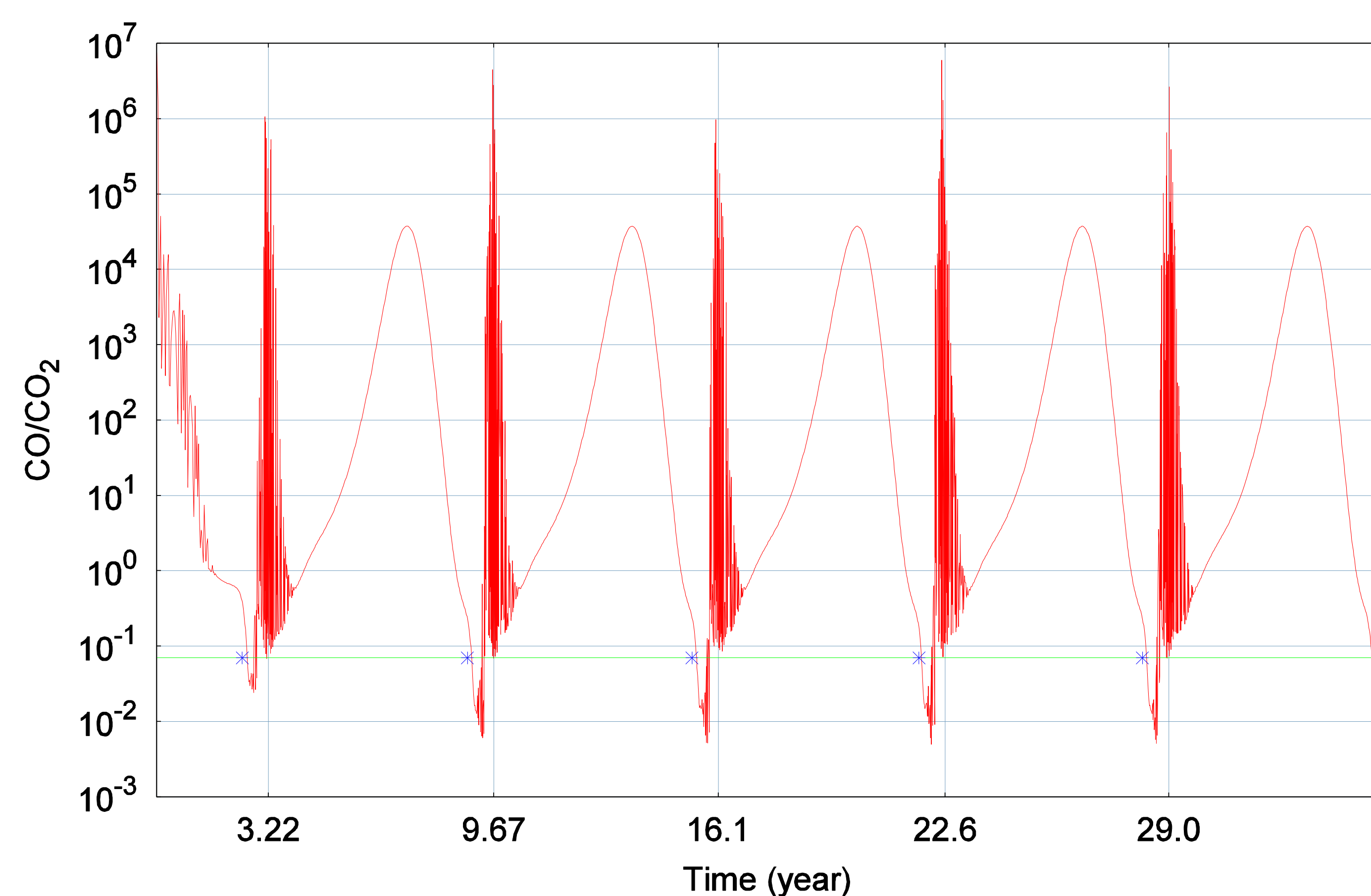


FIGURE 4. Evolution of the CO/CO₂ outgassing ratio at Abydos. The green line represents the *Ptolemy* value and the blue dots correspond to the measurement epoch (November 12, 2014). The *Ptolemy* value is matched with a 51 days difference (< 2% of error on 67P's year).

RESULTS AND DISCUSSION

We find that the best match of the *Ptolemy* measurements at a close time period of 67P's orbital evolution corresponds to CO/H₂O and CO₂/H₂O set at minimum and maximum respectively, giving CO/CO₂ = 0.46, and with a dust/ice ratio of 6 (porosity of 78%).

Assuming that the 67P's nucleus is a mixture of crystalline ices and dust, we find that high dust/ice ratios are needed at the subsurface of Abydos to match the CO/CO₂ value measured by *Ptolemy* at *Philae*'s landing epoch (November 12, 2014). Higher dust/ice ratios than those found in the comet literature are desirable if one wants to improve the time matching of the data. Our preliminary results suggest that 67P is heterogeneous.

MODEL AND PARAMETERS

We consider a mixture of crystalline ices (H₂O, CO and CO₂) and dust, with parameters updated from the recent *Rosetta* measurements (see **TABLE 1**). Based on the *ROSINA* observations [2], we assume CO/H₂O = 0.13±0.07 and CO₂/H₂O = 0.08±0.05 as a starting composition in the matrix. Two key parameters, the dust/ice mass ratio and the porosity, initially set at 4±2 [3] and 65±20% [4] respectively, are allowed to vary in the model (see **FIGURE 1**).

TABLE 1. List of physical and orbital parameters of 67P's nucleus used in this work.

Semi major axis	3.463 UA	Effective latitude of the Abydos site	- 21 °
Eccentricity	0.641	Bolometric Bond's albedo	6.5 · 10 ⁻²
Initial radius of the nucleus	2.43 km	Obliquity of the comet	52.25 °
Rotational period of the comet	12.4 h	Argument of sub-solar meridian at perihelion	- 111 °

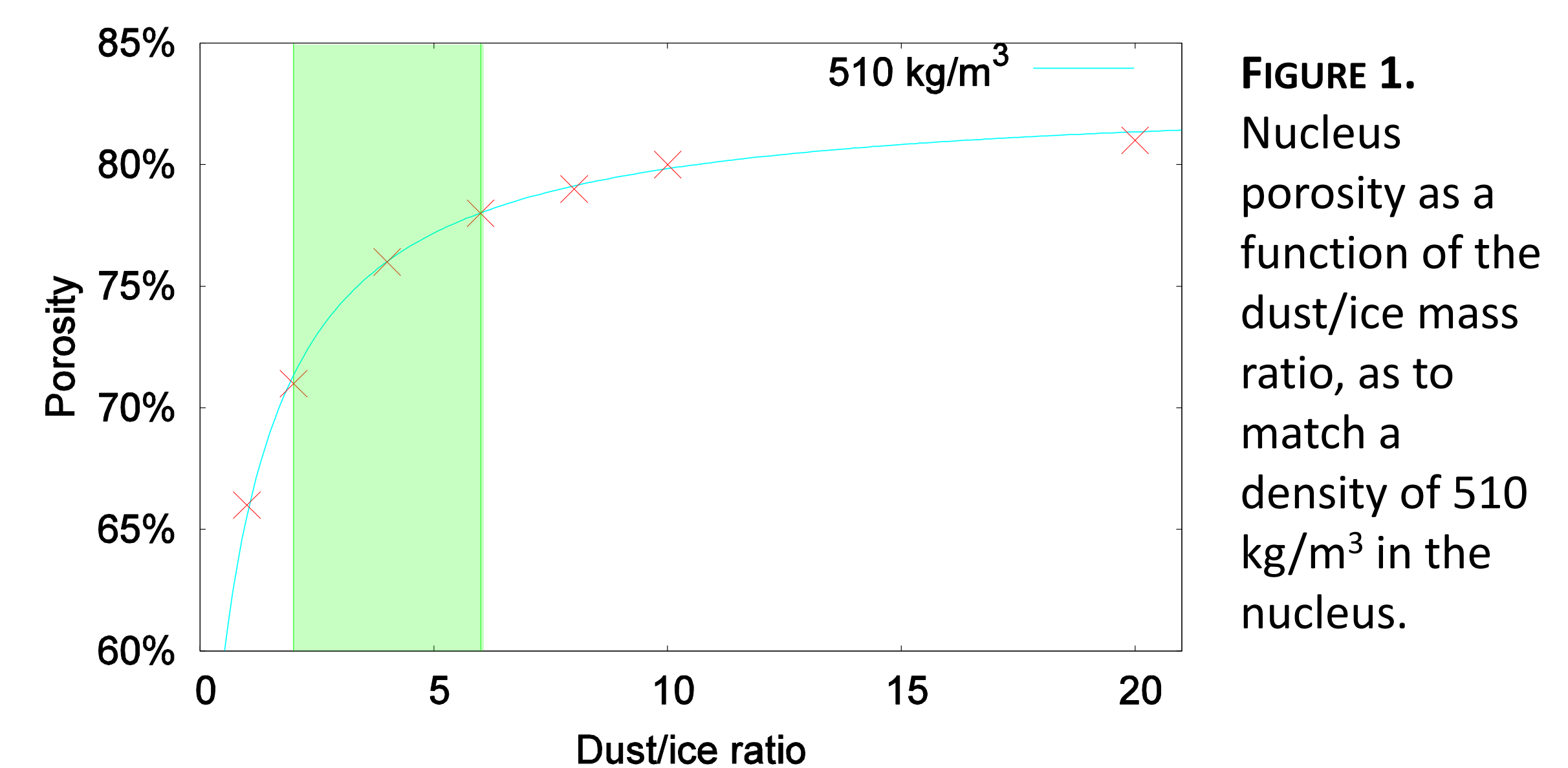


FIGURE 1. Nucleus porosity as a function of the dust/ice mass ratio, as to match a density of 510 kg/m³ in the nucleus.

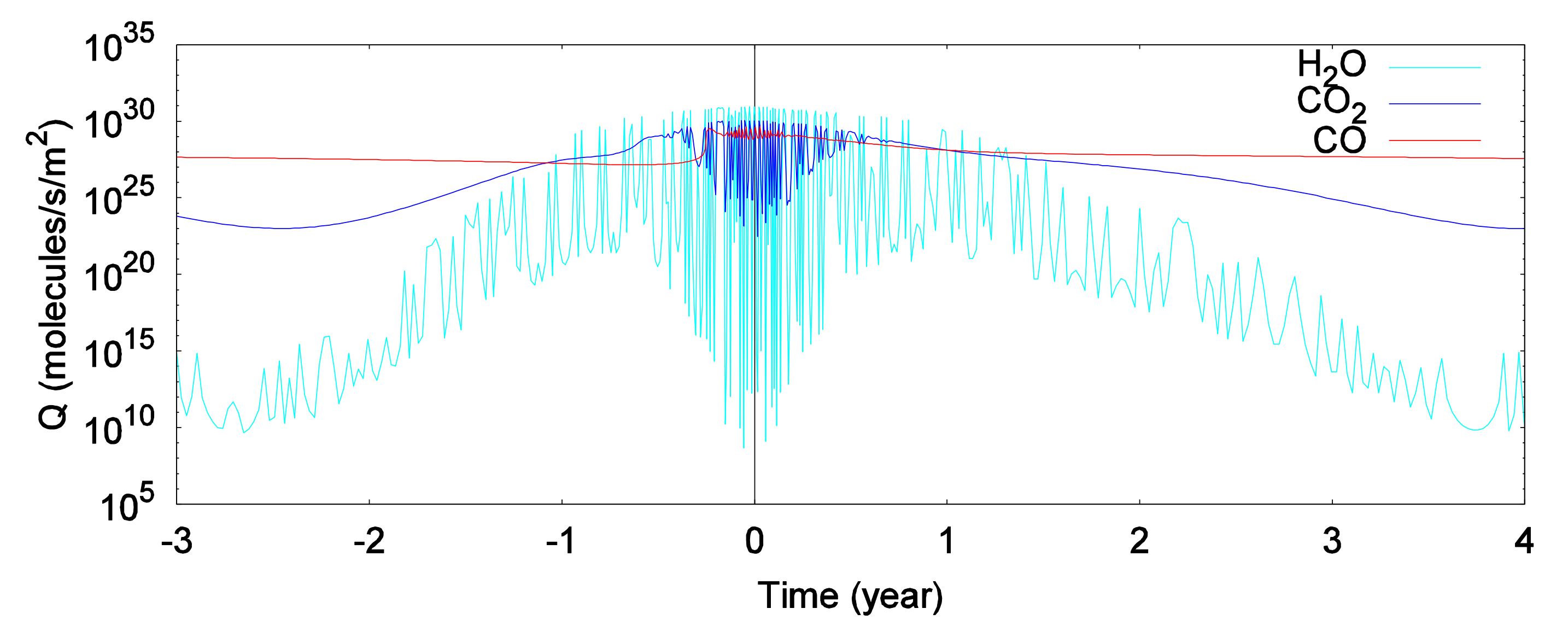


FIGURE 3. Outgassing profiles of all species at Abydos during one orbital evolution (perihelion occurs at 0 years). Peaks noticed for Q(H₂O), Q(CO) and Q(CO₂) correspond to the diurnal effects. The outgassing profile of each species varies as a function of the heliocentric distance, with an amplitude depending on the abundance and depth at which the species is buried in solid form (see **FIGURE 2**).

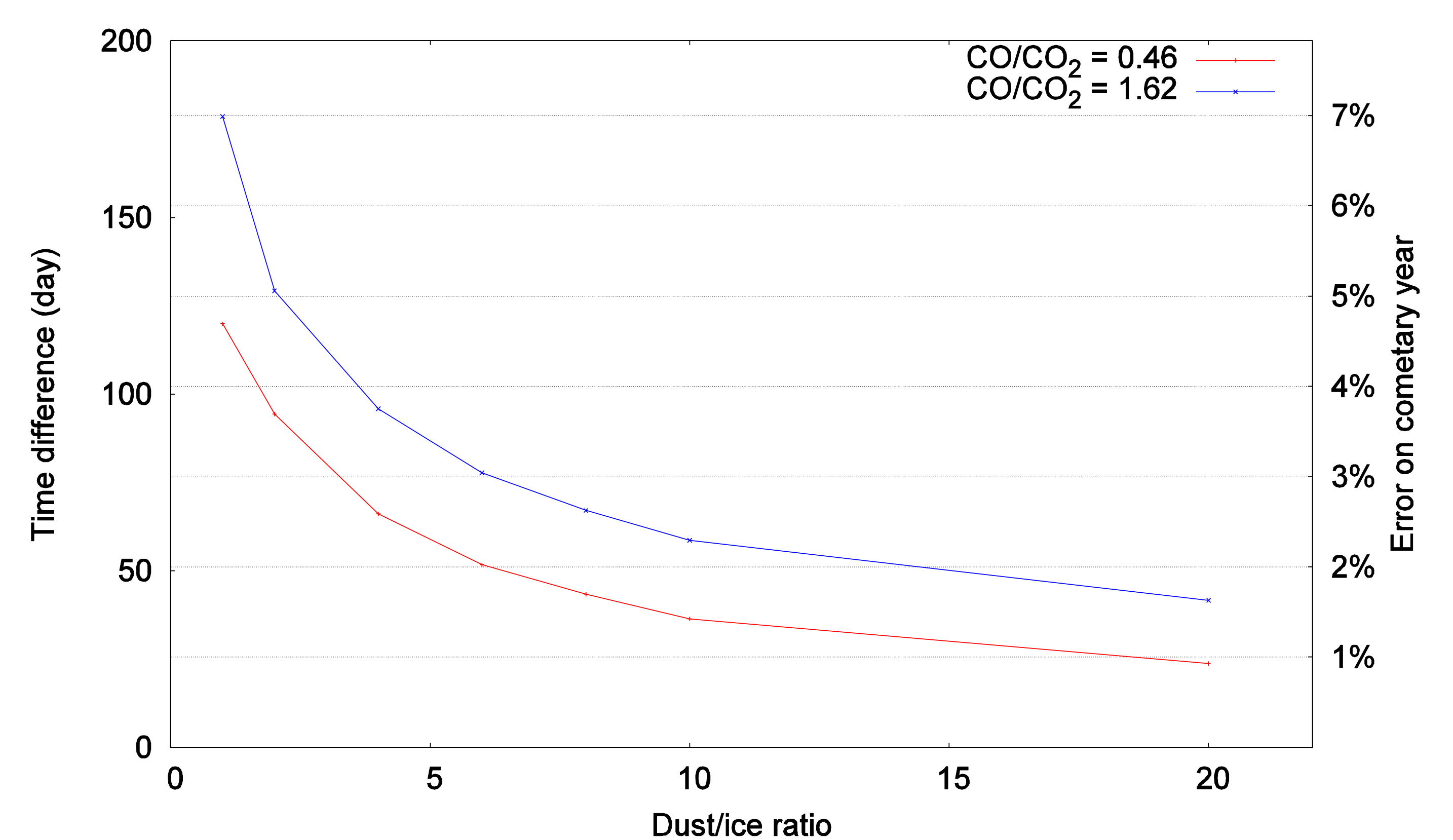


FIGURE 5. Influence of the dust/ice ratio on the time difference taken by the CO/CO₂ outgassing ratio to match the *Ptolemy* value at *Philae*'s landing epoch. This difference decreases with higher dust/ice ratios. For CO/CO₂ = 0.46 and dust/ice > 6, this difference is always under the 2% limit on a comet year.

REFERENCES

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